*Competency* 2.2 **Personnel shall demonstrate knowledge of contamination control, practices, procedures, and theory.**

## 1. SUPPORTING KNOWLEDGE AND/OR SKILLS

a. Define contamination and describe three types of contamination.

b. Describe three ways to control contamination.

c. Describe how contamination is detected.

d. Describe three ways contamination could enter the body and the methods used to prevent internal contamination.

e. Describe the methods used for internal dose determination.

f. Describe the types of personal protective equipment.

## 2. SUMMARY

Radioactive contamination is the presence of radioactive material in an unwanted place. Radioactive contamination can occur as:

- Fixed surface contamination
- Removable surface contamination
- Airborne contamination or any combination of the three

Fixed contamination can not be readily removed from a surface. It can not be removed by casual contact; however, it may be released if the surface is disturbed by activities such as buffing, grinding, sanding, or cleaning with a volatile solvent. Over time, fixed contamination may leach from the material containing it and become removable contamination.

Removable or transferable contamination is radioactive material that can be easily removed from a surface. It may be transferred by any casual contact such as touching, wiping, or brushing. Radioactive material suspended in the air is referred to as airborne contamination and it can be caused by occurrences such as air movement over removable contamination, a leak from a radioactive system, grinding on a surface with fixed or removable contamination, or a fire involving radioactive material.

Engineering controls, administrative controls, and personnel contamination control practices are used to control radioactive contamination. Engineering controls consist of structures or components designed to minimize or prevent the release of radioactive materials. Ventilation systems and containment systems are two examples of engineered controls. In general, ventilation systems are designed to move any potential airborne contamination away from personnel and to filter the radioactive material from the air. High Efficiency Particulate Air (HEPA) filters, personnel air locks, downdraft tables, hoods, and air movers are examples of ventilation system components that are used to control contamination. Containments are used to physically enclose radioactive material, thereby preventing it from becoming contamination. Containments include items such as vessels, pipes, cells, gloveboxes, glovebags, tents, huts, and plastic coverings.

Administrative controls are used to direct the actions of personnel in order to minimize the risk of exposure to radioactive contamination. Examples of administrative controls include postings to control access to contaminated areas and procedures to minimize or prevent the production of radioactive contamination.

Personnel contamination control practices are measures taken to use personal protective equipment to prevent personnel from becoming contaminated with radioactive material and they include:

- The use of precautionary clothing
- Anti-contamination clothing (Anti-Cs)
- Respiratory equipment

Surface contamination is monitored for by radiological control technicians (RCTs), who are required to routinely survey areas for potential contamination. Contamination monitoring equipment is primarily used to detect alpha particles; however, monitoring for beta particles and gamma rays also occurs. Surface contamination may be detected either by a direct frisk (holding the probe of a radiation detection instrument just above the monitored surface) or by smearing or swiping the surface with a paper or cloth swipe and monitoring the swipe for contamination. Direct frisking will detect fixed or removable contamination, while smearing will only detect removable contamination. When surface contamination is detected using the direct frisk method, a smear of the contaminated surface is taken to determine if the contamination is fixed or removable.

Airborne contamination is detected by specialized air monitoring equipment. Airhead samplers contain filters and are connected to vacuum systems so that the air being sampled will flow through the filter, while any particulate airborne radioactive contamination present will deposit on the filter. The filters are periodically removed and measured for radioactive contamination. Airhead samplers produce very accurate measurements of airborne contamination; however, they do not provide a timely indication of airborne contamination to warn workers. A Selective Alpha Air Monitor (SAAM) is a type of continuous air monitor used to measure airborne radioactive contamination and warn workers if the level rises above the alarm setpoint. Portable air samplers may also be used to measure airborne contamination if permanently installed SAAMs do not provide adequate coverage during maintenance or other activities.

Radioactive contamination can enter the body in four ways:
- Inhalation - breathing in radioactive material.
- Ingestion - eating or drinking radioactive material.
- Injection - radioactive material enters the body through an open wound or as a result of bodily injury such as a puncture wound.
- Absorption - radioactive material absorbed through the skin.

Internal contamination can be prevented by the proper use of contamination control practices and in particular, the use of engineering controls to isolate radioactive material from personnel. In some instances, however, personal protective equipment must be used as the last line of defense against internal contamination. In these cases, respiratory equipment (respirators, supplied air, Self

Contained Breathing Apparatus [SCBA], etc.) with an adequate protection factor can be used to prevent the inhalation or ingestion of radioactive material. Additionally, administrative controls to prohibit eating, drinking, smoking, and chewing tobacco may be used to minimize the risk of ingestion of radioactive materials.

The risk of internal contamination by injection can be reduced by minimizing operations where a sharp contaminated object could pierce a containment and injure personnel. Additionally, medical personnel are required to evaluate/decontaminate personnel wounds/cuts that occur to workers while they are in a radiological buffer area, airborne radioactivity area, contamination area, or high-contamination Area. The risk of internal contamination by absorption can be reduced by the appropriate use of personal protective clothing and prompt decontamination of the skin.

Bioassay samples, lung counting, and wound counting are three methods used in monitoring for internal contamination. A routine bioassay program is required by 10 CFR 835 for personnel if there is a likelihood that an intake of radioactive material could occur that would exceed specific limits as specified in §835.402 (c). Bioassay programs use urine samples, fecal samples, and nasal and mouth smears to determine the committed effective dose equivalent (CEDE) from internal contamination. Fecal samples are the most sensitive bioassay method for detecting internal plutonium contamination. The type of bioassay samples collected and the CEDE will depend upon many factors such as the radionuclide involved, the chemical form of the material, the route of entry, and the elapsed time since the intake occurred.

Lung counters are used to detect inhaled radioactive material in the lungs. The lung counter has a limited capacity for detecting internal contamination because it can only measure gamma rays. The amount of inhaled plutonium (Pu) must be estimated from the measured amount of gamma rays emitted from americium (Pu decay product). Lung counts can be used in conjunction with bioassay samples to determine CEDE.

Wound counters measure gamma rays and x-rays emitted by radionuclides deposited in a wound. Wound counts are primarily used as a tool to determine if internal contamination of a wound has occurred and to determine the successfulness of subsequent decontamination efforts.

In general, personal protective equipment used for radiological purposes can be divided into two main types: protection against internal contamination and protection against external contamination or sources. Respiratory protection is used to protect personnel from inhaling or ingesting radioactive material. Respirators (with the appropriate cartridge), supplied breathing air, and SCBA are examples of respiratory equipment used to prevent internal contamination. Protection factors are assigned to respiratory protection equipment that is used to determine the maximum level of airborne radioactive contamination against which the equipment can protect. Examples of equipment used to protect against external contamination or radiation sources include: Anti-Cs (protection against skin contamination), safety glasses (protection against beta to the eye), lead aprons (protection against gamma to reproductive organs), and lead-lined gloves (protection against skin contamination and gamma to hands). Requirements to use personal protective equipment are included in radiological work permits (RWPs) and on postings at area entry points.

## 3. SELF-STUDY ACTIVITIES/SCENARIOS AND SOLUTIONS

***Scenario 1***

A laboratory technician working in a glovebox detected contamination on the outside of her protective clothing after handling samples of Pu.

What immediate action should the technician take? Explain how the extent of contamination could be determined.

Assuming alpha contamination was involved and identified on the worker's arm, what actions should be taken or considered?

***Scenario 2***

A chemical operations employee accidentally bumped his knee while working in a radiologically contaminated area. This event broke open a scab from a previous wound. A radiological control technician (RCT) was notified; surveys of the worker's clothing did not reveal any contamination.

What follow up actions should be taken? What concerns are raised by this situation?

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***Scenario 3***

A radiological worker, attempting to exit the main guard gate at a DOE facility by passing through a large area detector, set off a radiation alarm. The worker had previously been in an area of the facility containing a test reactor and had already passed through a large area radiation detector. That detector had alarmed also, but a whole body frisk by the worker using a hand-held instrument did not detect any contamination. Since the work shift had ended, the worker decided to leave for the day when the detector at the guard gate, as noted above, alarmed.

Briefly discuss the discrepancy between the area monitor results and the personal contamination survey performed by the worker.

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***Scenario 1, Solution***
(Any reasonable paraphrase of the following is acceptable.)

The laboratory technician should notify appropriate radiological control personnel in order to initiate contamination control measures.

The extent of any external contamination can be determined by performing a thorough contamination survey of the worker. For alpha emitters, direct measurements should be performed by choosing an alpha detector with a reasonable background and adequate sensitivity. The detector should be placed within a quarter inch of accessible body surfaces and slowly moved over the areas of concern.

Where contamination is detected, established decontamination methods should be initiated. Because of the possibility of internal contamination, the collection of bioassay samples such as nasal, saliva, etc. should be performed. Calculations of the internal dose received by the worker may be required depending on the results of internal monitoring. Follow up monitoring, including additional bioassay measurements, should be considered.

The reasons for this contamination event should be examined. Failure to follow proper radiological work practices is one possibility. Another possibility is the loss of integrity of the glovebox gloves, conceivably through tears or pinhole leaks. The DOE *Radiological Control Manual,* (section 347) recommends inspections of gloveboxes prior to use and periodic monitoring of workers' hands during the performance of the work.

***Scenario 2, Solution***
(Any reasonable paraphrase of the following is acceptable.)

The breaking of the scab signals a possible internal contamination. The wound should be monitored by appropriate personnel to establish whether this is the case.

The DOE *Radiological Control Manual* does not define whether a scab is considered an open or closed wound. The worker may have believed that the scab was a closed wound and, therefore, did not require a bandage of some kind prior to entry into a contaminated area. For this situation, it may be appropriate for facility personnel to inform their employees that scabs are open wounds. Workers should be made aware of the potential hazards that are posed by partially-healed wounds.

***Scenario 3, Solution***
(Any reasonable paraphrase of the following is acceptable.)

Assuming the large area radiation detectors were functioning properly, it is conceivable that the worker did not perform an adequate whole-body frisk. Frisking requires the use of an appropriate instrument and proper survey technique. The probe must be passed slowly over the body in keeping with the response time of the instrument. The worker may have surveyed too quickly.

Since this was a reactor test area, it is not uncommon for radioactive decay products associated with the fission process to be present. These fission products are largely beta-gamma emitters and can be associated with microscopic particles of high specific activity (activity per mass). The large area radiation detectors apparently identified this source of contamination, but due to the particles' small size, they were not detected by the worker. This event underscores the need to perform contamination surveys in an appropriate manner.

## 4. SUGGESTED ADDITIONAL READINGS AND/OR COURSES

<u>Readings</u>


- Argonne National Laboratory. (1988). *Department of Energy Operational Health Physics Training* (ANL-88-26). Argonne, IL: Author.
- Gollnick, Daniel A. (1991). *Basic Radiation Protection Technology* (2nd ed.). Pacific Radiation Corporation: Altadena, CA.


<u>Courses</u>

- *Nuclear Physics/Radiation Monitoring* -- DOE
- DOE/EH-0450 (Revision 0), *Radiological Assessors Training (for Auditors and Inspectors) - Fundamental Radiological Control,* sponsored by the Office of Defense Programs, DOE.
- *Applied Health Physics* -- Oak Ridge Institute for Science and Education.
- *Health Physics for the Industrial Hygienist* -- Oak Ridge Institute for Science and Education.
- *Radiological Worker Training* -- DOE-EH.
- *Radiological Control Technician Training* -- DOE-EH.
- *Safe Use of Radionuclides* -- Oak Ridge Institute for Science and Education.
- *Radiation Protection General Technical Base Qualification Standard Training* -- GTS Duratek.